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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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EXAMINER	
KIELIN, ERIK J	

ART UNIT	PAPER NUMBER
2813	

DATE MAILED: 07/16/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/977,069	RAMANATH ET AL.	
	Examiner	Art Unit	
	Erik Kielin	2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *26 May 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *6-9,11 and 13-18* is/are pending in the application.

4a) Of the above claim(s) *none* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *6-9,11 and 13-18* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 26 May 2004 has been entered.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims **6**-8 and 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 5,079,600 (**Schnur** et al.) in view of ASM Handbook Vol. 5, Surface Engineering, ASM International: Matierals Park, Ohio, 1994, pp. 315-318, and the basic textbook by **Porterfield**, Inorganic Chemistry, A Unified Approach, Addison-Wesley: Reading, Massachusetts, 1984, pp. 487-488.

Regarding claim 6, **Schnur** discloses a semiconductor device comprising,

(a) a substrate (Fig. 1A);

(b) a diffusion barrier (Fig. 1A, called "thin film"), wherein the diffusion barrier comprises a self-assembled monolayer, SAM, (col. 10, lines 42-47) including a plurality of

molecules, each molecule having an aromatic group at the terminus of the molecule. (For example, EXAMPLE 28 at col. 21, discloses a SAM formed from trichloro-(4-pyridyl)-ethyl-silane which forms the equivalent SAM barrier layer as shown in structure entitled "1" on p. 7 of the instant specification. The pyridyl is an aromatic group.

(c) a metal layer (called "catalyst" and "metal layer") on the diffusion barrier.

In pertinent part, **Schnur** states in col. 20,

> "EXAMPLE 24
>
> "Fabrication of MOS capacitor test structures."
>
> "An n-type silicon wafer with a 100 nm thick thermal oxide layer was cleaned and treated with UTF3 as in example 14. The film was patterned using a mask with standard capacitor test structures and irradiated for 28 minutes with an Hg/Ar lamp. The wafer was metallized with the standard copper plating procedures, used in Example 5, yielding metal squares 800 microns on a side (area=$6x10^{-3}$ cm^2). The metal/thermal oxide/n-type silicon (MOS) capacitors were then characterized by probing the metal pads and the back of the wafer with a Micromanipulator automatic C-V measuring system. The capacitance was found to be 26 pF/cm^2 with minimal (10 mV) hysteresis and remained stable at room temperature for at over 3 weeks, indicating that device degradation due to masked metal contamination **(diffusion of copper into the thermal oxide) was not a problem**." (Emphasis added.)

Accordingly, it is seen to be inherent that the SAM of **Schnur** is a diffusion barrier because **Schnur** states that "diffusion of copper into the thermal oxide" does not occur.

(See also section entitled, "Summary of the Invention") the sections entitled "EXAMPLE 1" col. 11, lines 24-58 wherein the barrier layer is formed from "octenyldimethylchlorosilane" covalently bonded to the substrate. See also "EXAMPLE 3" and "EXAMPLE 5.")

It is held, absent evidence to the contrary, that the diffusion barrier is inherently capable of preventing the diffusion of copper atoms from the metal layer into the substrate when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm

at 200 °C in flowing N_2, because **Schnur** shows by empirical evidence that the SAM functions as a diffusion barrier. Because the **Schnur** SAM barrier layer it is the same exact molecule formed on a silicon substrate using the exact same precursor as used in the instant application, the barrier layer properties must be the same. **Schnur** also points out in Example 24 that copper diffusion does not occur even under the stress of an electric field.

Further in this regard, there exist no means for Examiner or the USPTO to determine the diffusion barrier properties of the **Schnur** barrier layer under the specific conditions that Applicant is claiming. Simply because Applicant ran a test for diffusion barrier properties under a specific set of conditions does not make the diffusion barrier novel and non-obvious over the barrier layer of **Schnur**. Applicant has the burden of proof of showing that the Schnur copper barrier layer does not operate as barrier layer under the claimed conditions. To do otherwise would take away from the public that which has already been given to the public many years ago by **Schnur**. See *In re Swinhart*, 169 USPQ 226,229 (CCPA 1971) (where the Patent Office has reason to believe that a functional limitation asserted to be critical for establishing novelty in the claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the **applicant to prove that subject matter shown to be in the prior art does not possess the characteristics relied on**) and *In re Fitzgerald*, 205 USPQ 594 (CCPA 1980) (the burden of proof can be shifted to the applicant to show that subject matter of the prior art does not possess the characteristic relied on whether the rejection is based on inherency under 35 USC 102 or obviousness under 35 USC 103). Note that as long as there is evidence of record establishing inherency, failure of those skilled in the art to contemporaneously recognize an

inherent property, function or ingredient of a prior art reference does not preclude a finding of anticipation. (See MPEP 2112.)

Schnur does not teach that the catalyst is copper, thereby having the limitation that "for each molecule of the plurality of molecules, the copper in the metal layer is in direct contact with the aromatic group of the molecule."

ASM Handbook teaches that copper may be used as a catalyst for electroless plating of copper (pp. 315-318 --especially p. 318 sections entitled, "Catalyzation" and "Copper catalyst"). The basic textbook of **Porterfield** ensures that copper forms metal complexes with pyridine groups, such as the pyridine group used in **Schnur** as the polar end-group of each molecule in the SAM barrier layer.

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use copper as the metal catalyst in **Schnur** as taught in the **ASM Handbook** because **Schnur** is not limited to Pd/Sn catalysts, as at least claim 1 of **Schnur** makes clear, and because copper is a known catalyst for electroless copper plating, as used in **Schnur**, as taught by the **ASM Handbook**. In this regard, it has been held that the selection of a known material based upon its suitability for an intended purpose is obvious. Moreover, the **ASM Handbook** teaches that copper-based catalyst are less expensive that palladium-based catalyst, thereby providing additional motivation to use copper for cost savings.

Schnur only requires that the catalyst bond to polar end group of the molecule which is the pyridyl end group of "Example 28" in **Schnur**. **Porterfield** ensures that such bonding occurs, such the one of ordinary skill has a reasonable expectation of success for using copper instead of Pd/Sn, as the catalyst in **Schnur**. Accordingly, using copper as the catalyst gives the

limitation, that "for each molecule of the plurality of molecules, the copper in the metal layer is in direct contact with the aromatic group of the molecule."

Regarding claim 7, as noted above, Example 24 in **Schnur** states that the substrate is a silicon wafer with silicon oxide formed thereon.

Regarding claim 8, **Schnur** discloses the linear carbon chain of trichloro-(4-pyridyl)-ethyl-silane is the ethyl group, which has at least 2 carbon atoms.

Regarding claim 12, the metal layer is in direct contact with the terminal groups of the molecules in self-assembled monolayer (Fig. 1A). Note that the "catalyst" is a metal and therefore forms part of the "metal layer."

4. Claims 9, 11, and **13**-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Schnur** in view of the **ASM Handbook** and **Porterfield**, as applied to claims 6-8 and 10 above, and further in view of **Wolf**, et al. Silicon Processing for the VLSI Era, Vol. 1-Process Technology, 2nd ed., Lattice Press: Sunset Beach CA, 2000, pp. 438, 782-783.

Regarding claims 9 and 13, **Schnur** discloses each of the claimed features, as explained above, but does not indicate that the metal layer is deposited by a vapor deposition process, using in the exemplary embodiments, electroplating. **Schnur** does, however, indicate that the metal deposition method is for use in interconnect for semiconductor microcircuitry (Abstract, Example 25 in col. 20.)

The basic textbook of **Wolf**, teaches that copper metal interconnect may be deposited by a variety of methods, including electroplating and vapor deposition methods such as PVD (e.g. sputtering) and CVD. (See pp. 782-783--especially p. 783, last paragraph before section 15.8.2.)

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use a vapor deposition process, such as sputtering to deposit the metal layer in **Schnur**, because vapor deposition processes (i.e. PVD and CVD) are an art recognized equivalent means to the electroplating used in **Schnur** to form copper interconnect, as taught by **Wolf**.

Further regarding claim 13 and regarding claim 17, it is held, absent evidence to the contrary, that the diffusion barrier of **Schnur** is capable of preventing the diffusion of metal atoms from the metal layer into the substrate when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm at 200 °C in flowing N_2 (claim 17) and that the semiconductor device does not exhibit $j_{leakage} > 1000\ nAcm^{-2}$ when the semiconductor device is exposed to thermal annealing at 200 °C or an electric field of 2 MV/cm in flowing N_2 at 200 °C for up to 650 minutes (claim 19). The basis for this reasoning is the same as applied to claim 10 above whose arguments are incorporated herein in their entirety. In short, equivalent structures must be capable of serving the same function. The structures in the instant specification are equivalent to those disclosed in **Schnur**.

Regarding claim 11, in Example 25 (col. 20) in **Schnur** the diffusion barrier coats the walls of a polysilicon steps, but it is unclear if the metal fills a hole in the substrate. But as noted above, **Schnur** states that the method is used for interconnect.

The basic textbook of **Wolf** teaches that copper interconnect fills a hole in a substrate lined with a barrier layer to form interconnect for semiconductor microcircuitry (Fig. 15-52, pp. 782-783).

It would have been obvious for one of ordinary skill in the art, at the time of the invention to form the metal interconnect of **Schnur** in a hole, because **Wolf** teaches that this is standard practice in the art for forming copper interconnect.

Regarding claims 14 and 18, as noted above with respect to claim 7, Example 24 in **Schnur** states that the substrate is a silicon wafer with silicon oxide formed thereon.

Regarding claim 15, as noted above with respect to claim 8, **Schnur** discloses that the linear carbon chain of trichloro-(4-pyridyl)-ethyl-silane is the ethyl group, which has at least 2 carbon atoms.

Regarding claim 16, although **Schnur** does not teach sputtering, as noted above with respect to claim 9, **Wolf** teaches that PVD (of which sputtering is a member; Wolf, p. 438) is an art recognized means to electroplating to deposit metal films for interconnect.

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use a vapor deposition process, such as sputtering to deposit the metal layer in **Schnur**, because vapor deposition processes (i.e. PVD and CVD) are an art recognized equivalent means to the electroplating used in **Schnur** to form copper interconnect, as taught by **Wolf**.

Response to Amendment

5. The declaration under 37 CFR 1.132 filed 26 May 2004 is insufficient to overcome the rejection of (1) claims **6**-8 and 10 based under 35 U.S.C. 103(a) over **Schnur** in view of the ASM Handbook Vol. 5, Surface Engineering and the basic textbook by **Porterfield**, Inorganic Chemistry, A Unified Approach, or (2) claims 9, 11, and **13**-18 under 35 U.S.C. 103(a) over

Schnur in view of the **ASM Handbook** and **Porterfield**, and further in view of **Wolf** as set forth in the last Office action for the reasons presented below.

Regarding items 4 and 5 of the declaration, co-inventor Ramananth opines,

> "I believe that these barrier layer properties are not taught or suggested by Schnur et al., either expressly or inherently. While the Office Action suggests at pages 5-6 of the Office Action that properties such as these are 'inherent' Applicants' data in FIG. 3 of the present application show that different molecules exhibit different barrier layer properties. Accordingly, contrary to the Office Action's allegation, I believe that it cannot be presumed that the properties recited in the claims are 'inherent'."

First, the molecules of the SAM **are exactly the same** in Schnur as in the instant disclosure, as has been pointed out numerous times in the Office actions mailed. Schnur discloses numerous SAM molecules having aromatic end groups, such as trichloro(4-pyridyl)-ethyl-silane (Schnur, col. 21, "EXAMPLE 28") --which is the exact same SAM molecule as used in the instant application. Others having an aromatic end groups disclosed in Schnur are cholortriphenylsialne, diphenylvinylchlorosilan, and p-cholormethylphenyltrichlorosilane (Schnur, col. 22, last paragraph). Accordingly, this argument is moot. Second, given that the molecules of the SAM **are exactly the same** in Schnur as in the instant disclosure, Applicant is required to provide more than mere speculation. Empirical evidence is required.

Further regarding paragraph 5 in the declaration, co-inventor Ramanath declares that SAM molecules with aromatic groups provide **superior** diffusion barrier properties. First Applicant cannot deny that the disclosed Schnur molecules have barrier layer properties based upon the facts disclosed in Schnur. Second, based upon Ramanath's declaration that aromatic groups provide **superior** diffusion barrier properties, Ramanath's declaration only supports the

validity of the inherency argument that the Schnur SAM molecules with aromatic end groups will meet the required barrier layer properties, since Schnur discloses SAM molecules having aromatic end groups --specifically **the exact same SAM molecule** disclosed in the instant application, trichloro(4-pyridyl)-ethyl-silane.

Regarding paragraph 6 of the declaration, co-inventor Ramanath argues that because the exact same molecule, trichloro(4-pyridyl)-ethyl-silane, was deposited on a glass slide and not on a semiconductor wafer, that its diffusion barrier properties were not tested. This is irrelevant because the SAM, trichloro(4-pyridyl)-ethyl-silane, is still for use as both a barrier layer (based upon EXAMPLE 24 of Schnur) and for plating of copper metal for interconnect in semiconductor devices, as expressly disclosed in Schnur. Accordingly, it is not novel and non-obvious to follow the teachings of Schnur and make some different observation which is inherently present in the SAM molecule used in Schnur. Schnur shows that his SAMs have diffusion barrier properties.

Note that it has been held that the claiming of a **new use, new function** or **unknown property which is inherently present in the prior art** does not necessarily make the claim patentable. See *In re Best*, 562 F.2d 1252, 1254, 195 USPQ 430, 433 (CCPA 1977). Anticipation by a prior art reference **does not require** either the inventive concept of the claimed subject matter or **the recognition of inherent properties** that may be possessed by the prior art reference. See *Verdegaal Bros. Inc. v. Union Oil Co.*, 814 F.2d 628, 633, 2 USPQ2d 1051, 1054 (Fed. Cir.), cert. denied, 484 U.S. 827 (1987). A prior art reference anticipates the subject matter of a claim when the reference discloses every feature of the claimed invention, either explicitly or **inherently**. See *Hazani v. Int' l Trade Comm'n*, 126 F.3d 1473, 1477, 44 USPQ2d 1358, 1351

(Fed. Cir. 1997) and *RCA Corp. v. Applied Digital Data Systems, Inc.*, 730 F.2d 1440, 14.44, 221 USPQ 385, 388 (Fed. Cir. 1984). The law of anticipation does not require that the reference teach what the appellants are claiming, but only that the claims on appeal "read on" something disclosed in the reference. See *Kalman v. Kimberly-Clark Corp.*, 713 F.2d 760, 772, 218 CSPQ 781, 789 (Fed. Cir. 1'983), cert. denied, 465 U.S. 1026 (1984).

Regarding paragraph 7 in the declaration, co-inventor Ramanath argues that vapor deposition is different than electrodeposition. While not arguing that they may be different, there exists no evidence that that electrodepositing and vapor deposition will have any impact on the diffusion barrier properties of the SAM barrier layer. Evidence of record exists in Schnur and in the instant invention that the SAM works as a diffusion barrier regardless of the method of deposition of the overlying copper layer. Accordingly, this point is moot. Moreover, given that rejection of the claims, vapor deposition is known in the art and does not make the claimed SAM barrier layer or the structure including it novel for reasons of record.

Response to Arguments

6. Applicant's arguments filed 26 May 2004 have been fully considered but they are not persuasive.

Applicant again argues that the ASM Handbook teaches away from the use of copper catalysts. Examiner respectfully but emphatically disagrees for reasons indicated in the previous Office action filed 24 November 2003, repeated here for Applicant's convenience. While Examiner acknowledges that the ASM Handbook indicates that there exists a "major

disadvantage," the ASM Handbook in the two sentences directly preceeding that sentence quoted from the ASM Handbook by Applicant states,

> "*Copper catalyst*: Because **palladium is more expensive** than the less noble metals (such as copper and nickel) that are known to be autocatalytic, there have been numerous attempts to develop a viable catalyst based on one of these metals. **A copper-tin colloidal catalyst was first reported in 1976 (Ref 59) and has proven commercially successful in a number of installations**." (Italicized emphasis in original; bold emphasis added.)

Accordingly, not only has the "major disadvantage" apparently been successfully avoided -- owing to the proven commercial success of copper-tin catalyst-- one of ordinary skill gains the added benefit of a less expensive material than palladium which will save money, as is always highly desired in the highly competitive art of semiconductor device manufacturing.

For this reason, it is improper for Applicant to argue,

> "There is **no motivation** to modify Schnur et al. with the teachings of ASM, because the cited references explicitly teach away from the modification proposed by the Examiner." (Emphasis added.)

This statement is factually in error given that the ASM Handbook suggests the proposed modification to save money and that copper-based catalysts have been proven commercially successful. Rather Applicant has ignored the express teachings of the ASM Handbook and has taken a single sentence out of context as if that were all the ASM Handbook were teaching.

Regarding Applicant's argument that the references must be looked at as a whole, Examiner agrees and has done so. There would be no reason whatsoever for the ASM Handbook to include useless irrelevant information. One of ordinary skill would be motivate to use Cu/Sn as a seed layer to save money. Accordingly, there is no motivating away from using Cu/Sn. Rather there exists a motivation to used it --to save money. Note further that it has been held,

> "The use of patents as references is not limited to what the patentees describe as their own inventions or to the problems with which they are concerned. They are part of the literature of the art, relevant for all they contain." *In re Heck*, 699 F.2d 1331, 1332-33, 216 USPQ 1038, 1039 (Fed. Cir. 1983) (quoting *In re Lemelson*, 397 F.2d 1006, 1009, 158 USPQ 275, 277 (CCPA 1968)). A reference may be relied upon for all that it would have reasonably suggested to one having ordinary skill the art, including nonpreferred embodiments. *Merck & Co. v. Biocraft Laboratories*, 874 F.2d 804, 10 USPQ2d 1843 (Fed. Cir.), cert. denied, 493 U.S. 975 (1989). See also *Celeritas Technologies Ltd. v. Rockwell International Corp.*, 150 F.3d 1354, 1361, 47 USPQ2d 1516, 1522-23 (Fed. Cir. 1998) (The court held that the prior art anticipated the claims **even though it taught away from the claimed invention**. "The fact that a modem with a single carrier data signal is shown to be less than optimal **does not vitiate the fact that it is disclosed**."). Disclosed examples and **preferred embodiments do not constitute a teaching away from a broader disclosure or non-preferred embodiments**. *In re Susi*, 440 F.2d 442, 169 USPQ 423 (CCPA 1971). "A known or obvious composition does not become patentable simply because it has been described as somewhat inferior to some other product for the same use." *In re Gurley*, 27 F.3d 551, 554, 31 USPQ2d 1130, 1132 (Fed. Cir. 1994).

For at least these reasons, Applicant's argument is not persuasive --especially since there is a beneficial reason for using Cu/Sn seed layers, as expressed in ASM Handbook.

The remainder of Applicant's arguments are those presented in the declaration of co-inventor Ramanath, which were addressed above and are not effective in overcoming the rejections.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Erik Kielin whose telephone number is 571-272-1693. The examiner can normally be reached on 9:00 - 19:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead, Jr. can be reached on 571-272-1702. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Erik Kielin
Primary Examiner
15 July 2004